MonoCam Astrometry

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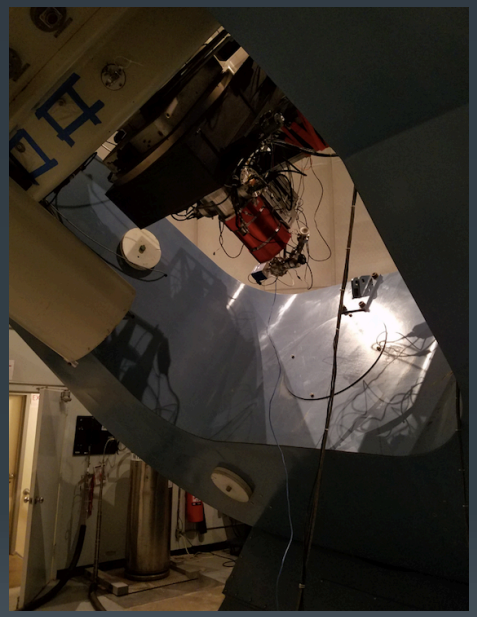
What is/Why astrometry?

- We take catalog stars with a very well known position and compare them with the measured star positions taken from observed data (e.g. MonoCam)
- Comparison with catalog stars can reveal important information about possible sensor defects, precision capabilities, etc.
- We want to look for any sensor defects and try to quantify how well MonoCam holds up to LSST astrometry specifications

Monocam at the 61 inch Telescope



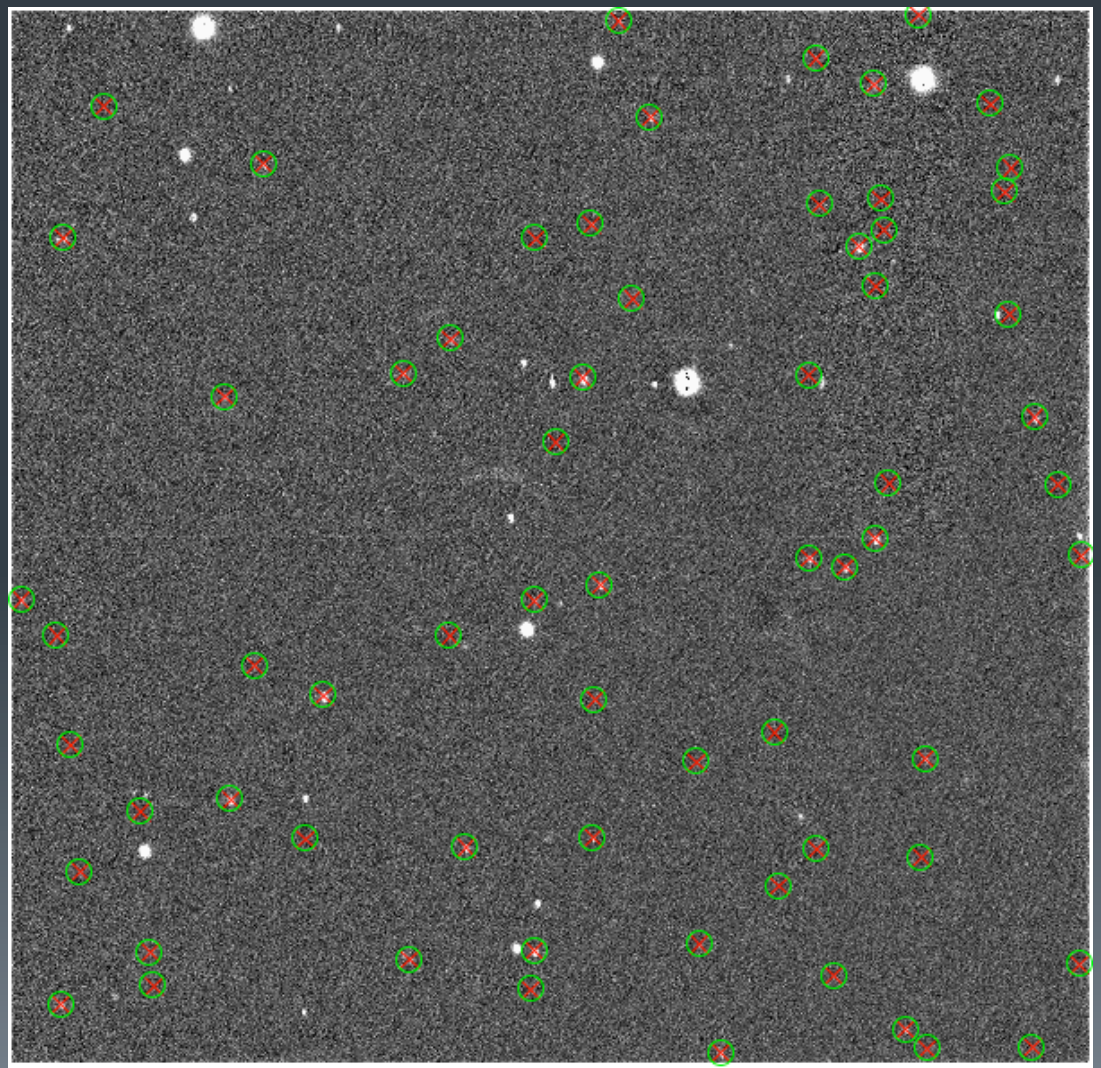
- scale 13.5 arcsec/mm
- f/9.8
- FOV 0.15 x 0.15 sq.deg.
- Studied two star fields:
  - First field:
    - RA 13 16 30.05
    - DEC +29 06 02.9
  - Second field:
    - RA 15 32 09.69
    - DEC +13 56 15.9

61 inch Telescope
Image and details can be found at http://www.nofs.navy.mil/

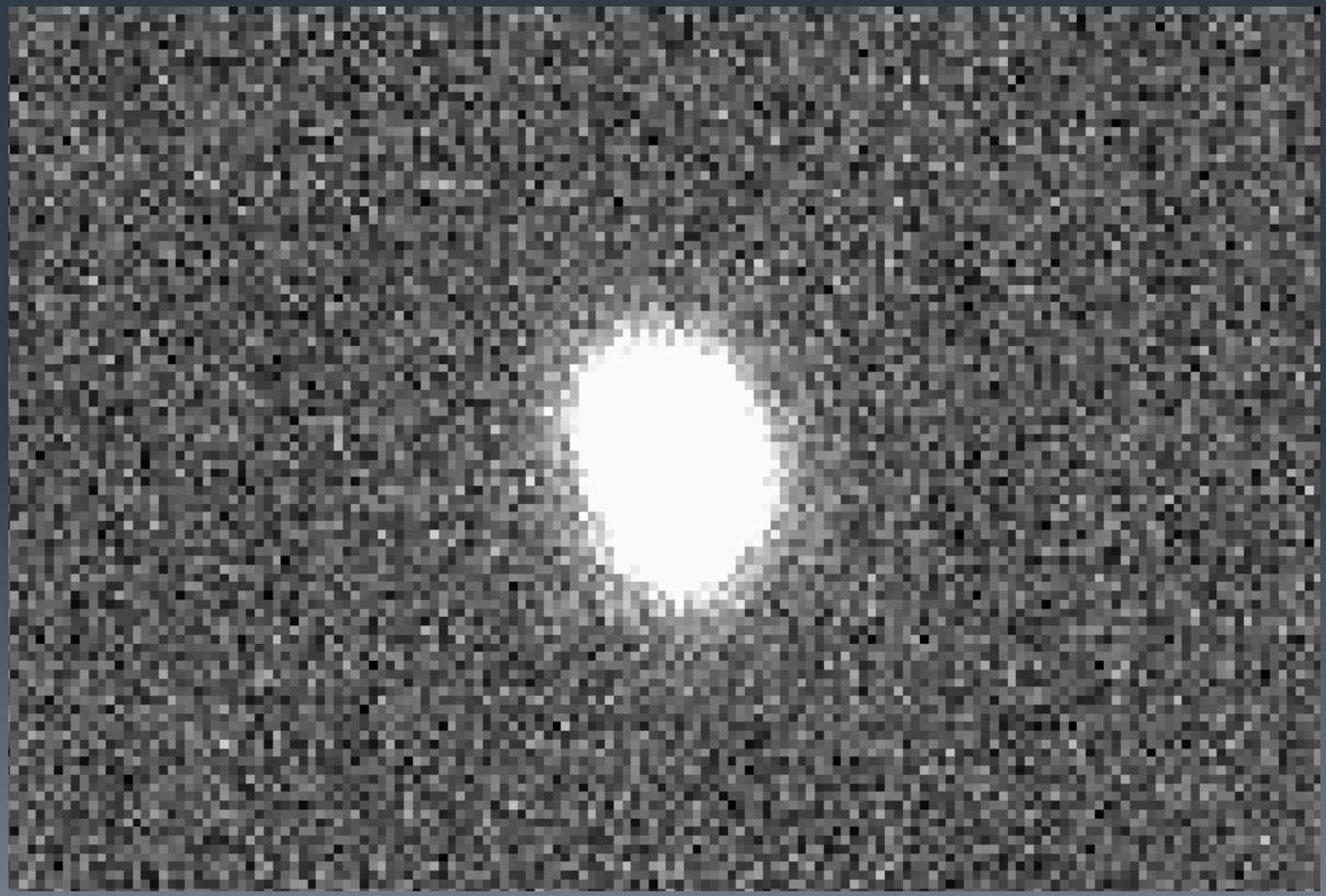
Image specifications

- calexp images
  - All images are bias corrected (but not dark or flat corrected)
  - 300 second exposure times, five dithers x four filters
  - 58 out of 80 images made it to calexp (SDSS and Gaia catalog)
  - Possible flat fielding issues?
- Images processed with v13.0 of the DM stack
  - Used old astrometry.net matcher for astrometry with SDSS catalog
  - Newer DM stack matcher for Gaia catalog
- MonoCam 61 inch telescope GRIZ filters
- Took data on two days: 2016-05-04 and 2016-05-05, camera was rotated 90 degrees between these two days

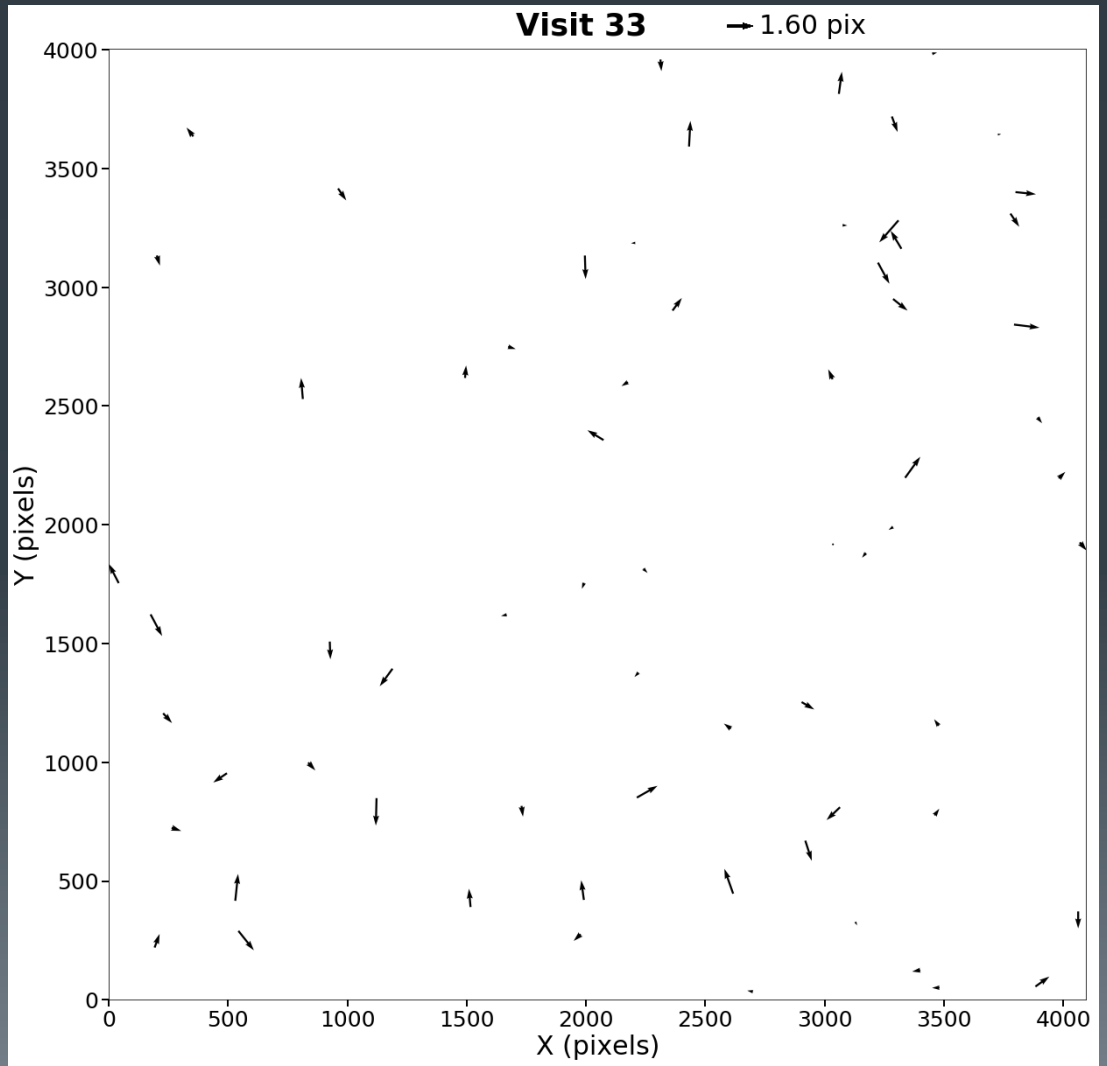
Source (green circle, MonoCam measured) and catalog stars (red x)



Sample PSF

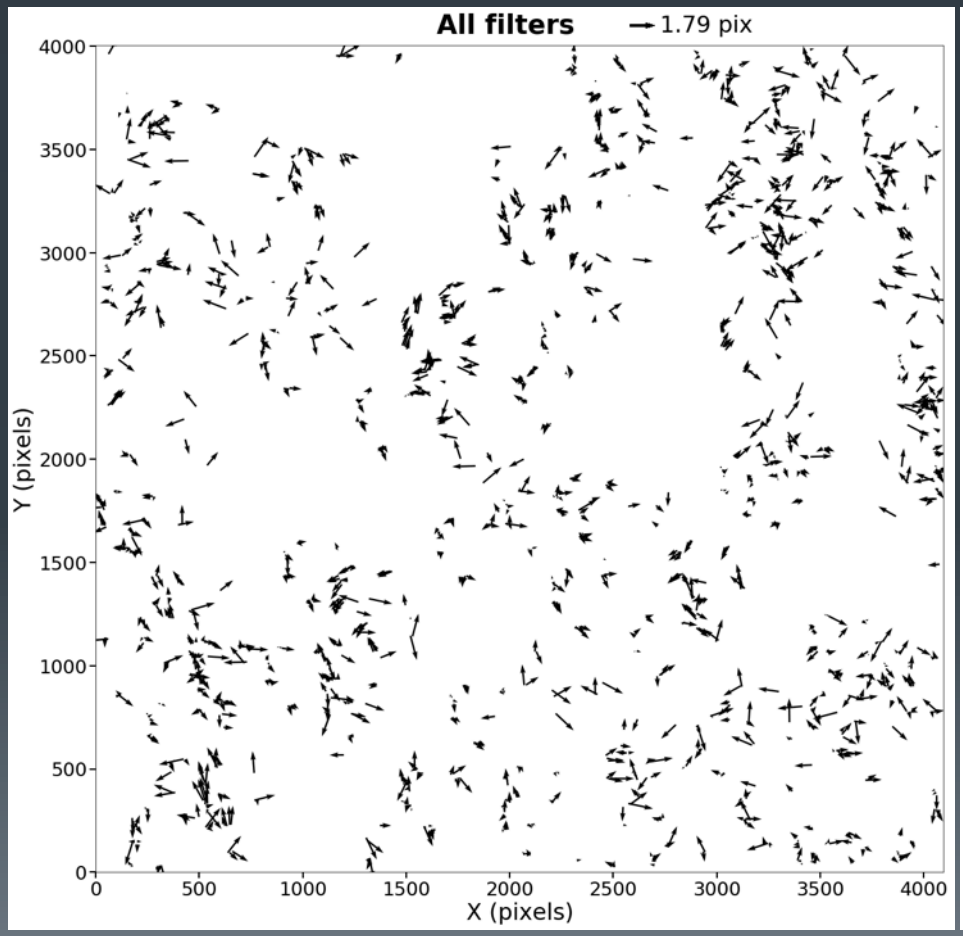


Matching results (SDSS catalog)

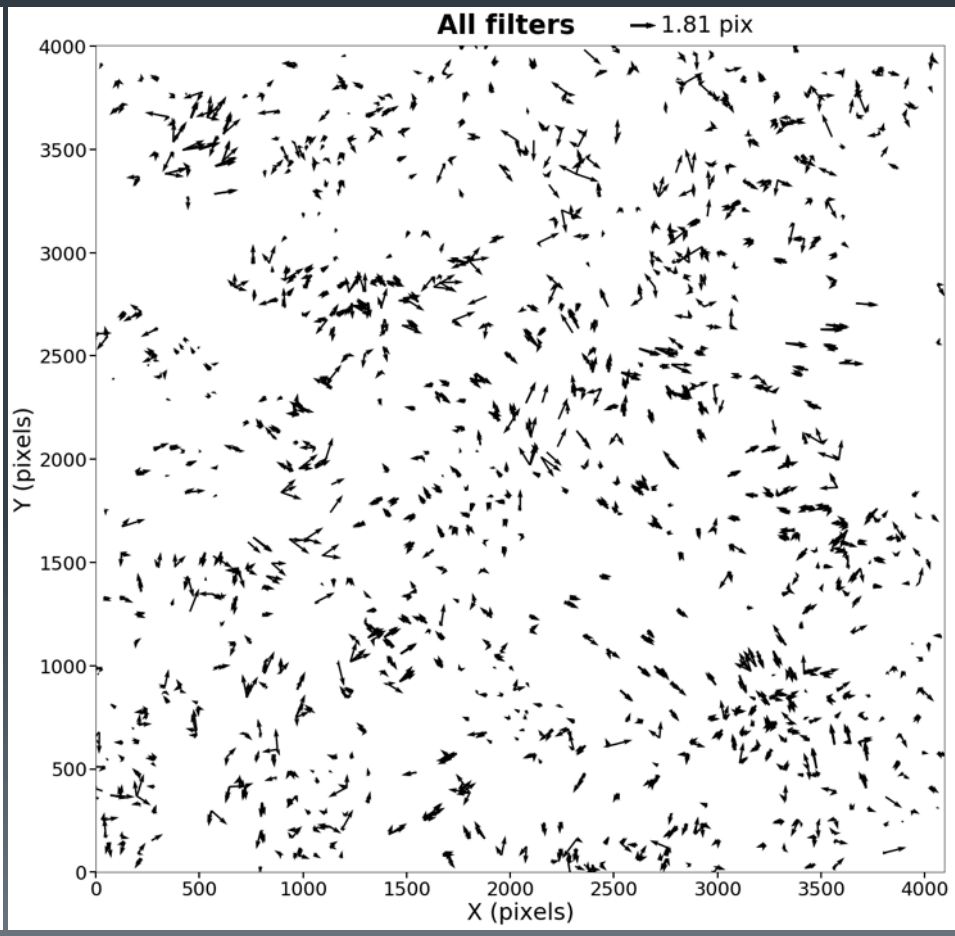


2016-05-04 vs 2016-05-05 (SDSS catalog)

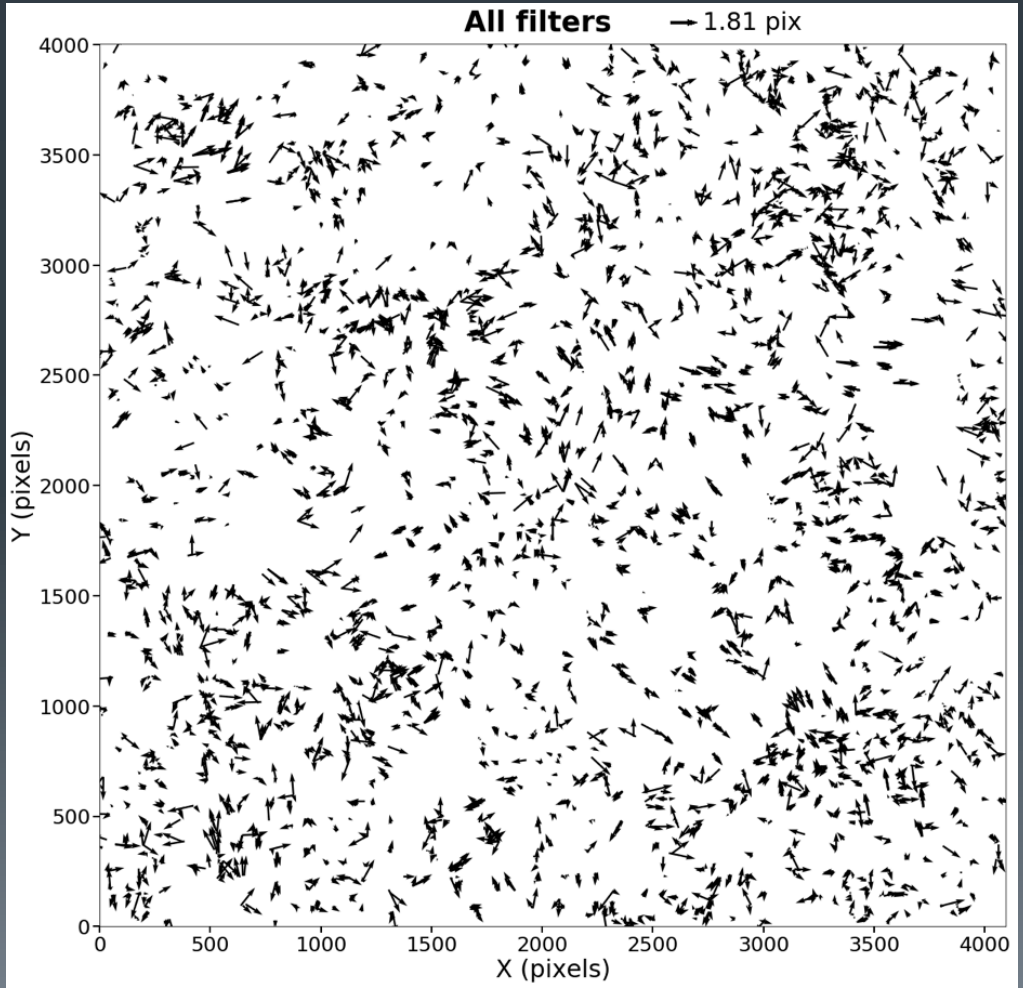
2016-05-04



2016-05-05

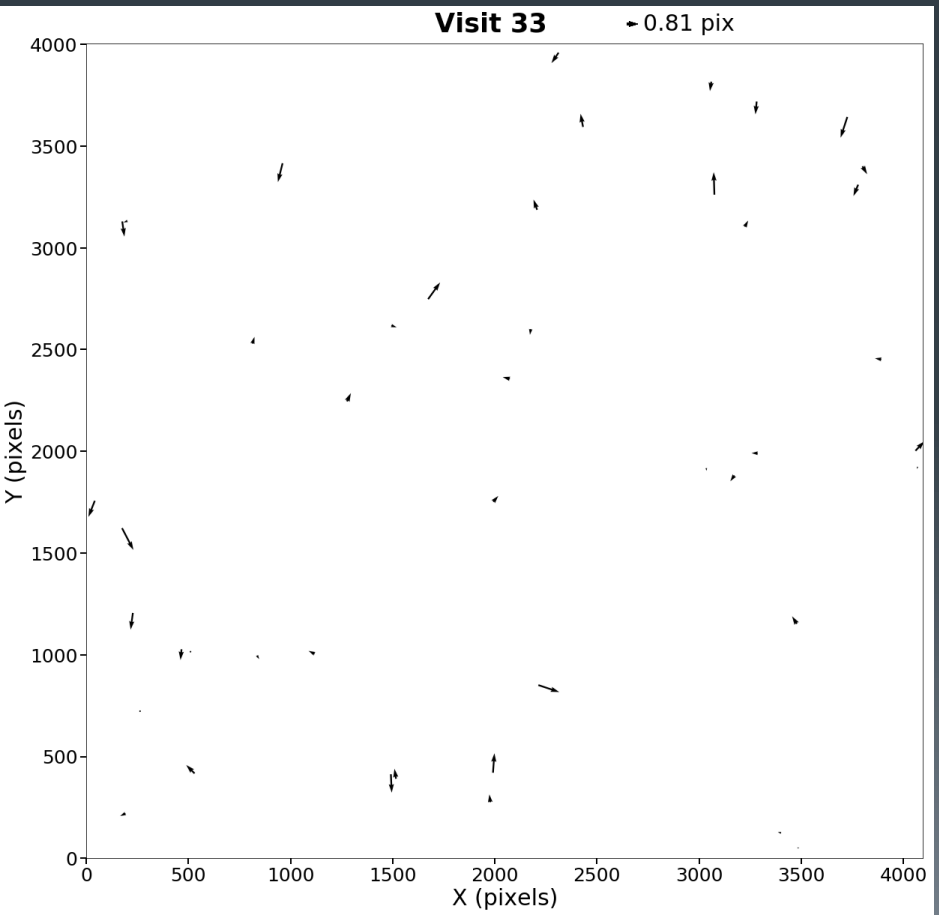


All filter results (SDSS catalog)

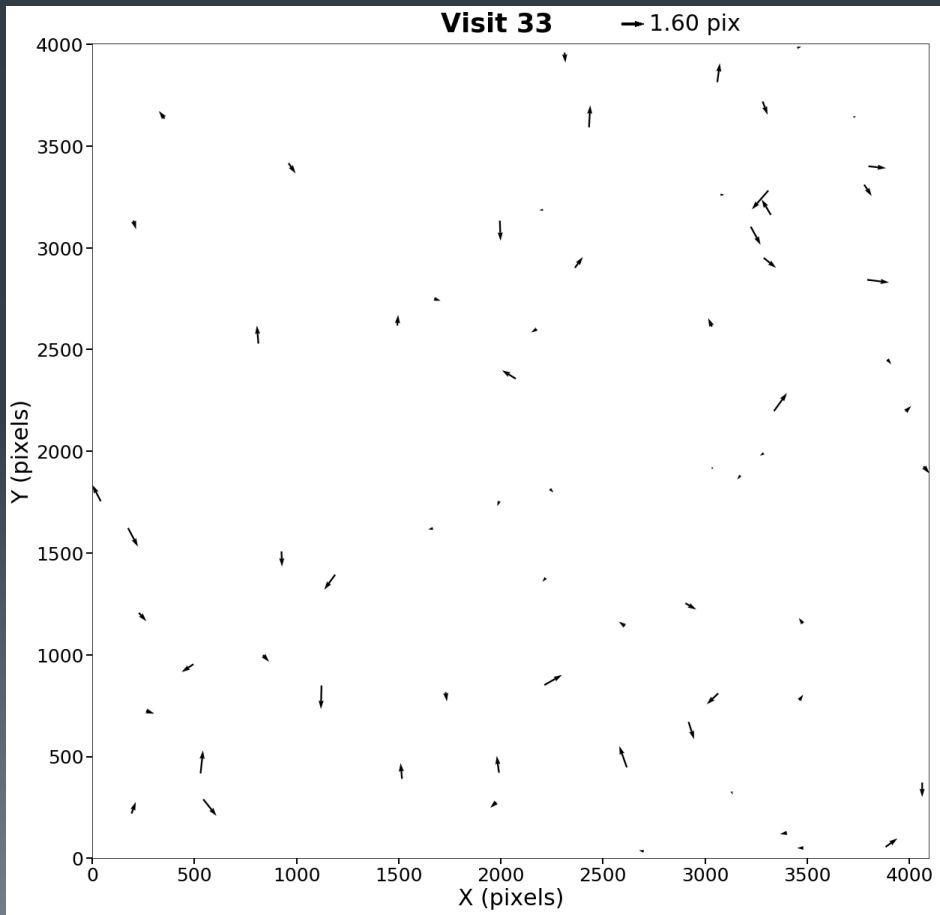


Gaia vs SDSS: similar results

Gaia residual plot, arrows point from source star to catalog star

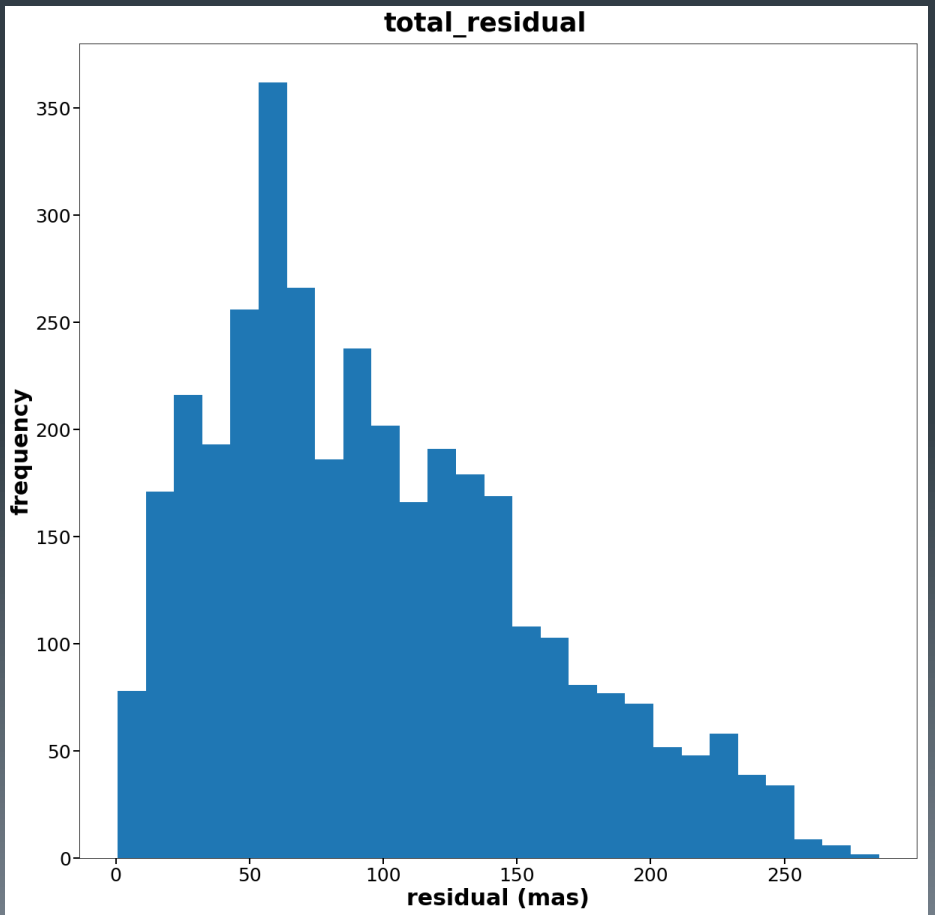


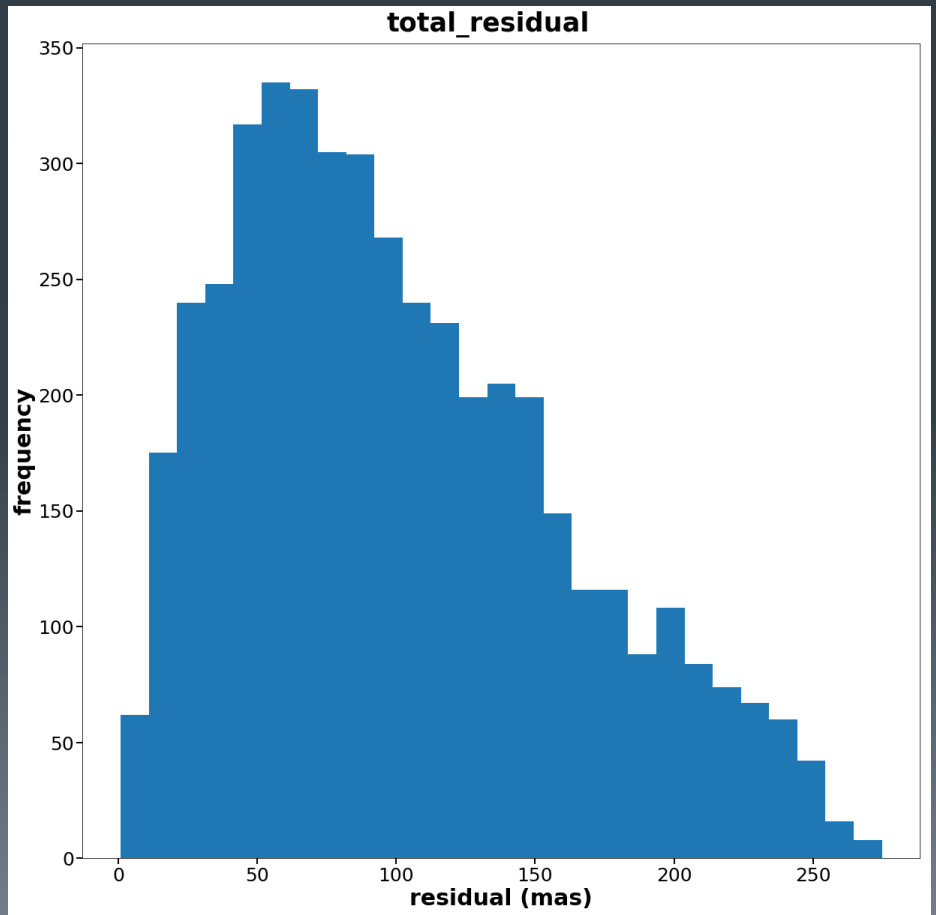
SDSS residual plot



Gaia vs SDSS cont'd

- Gaia:
  - Mean 97.42 mas
  - Median 86.96 mas
  - 3562 total matches
  - Rejected matches >5 pix apart
- SDSS:
  - Mean 102.2 mas
  - Median 91.31 mas
  - 4588 total matches



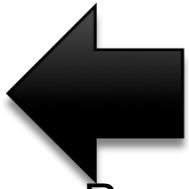


LSST specifications: relative astrometry

From
http://www.astro.washington.edu/users/ivezic/Publications/LSSTSRDv5.2.3.pdf

"The rms of the astrometric distance distribution for stellar pairs with separation of D arcmin (repeatability) will not exceed AMx milliarcsec (median distribution for a large number of sources). No more than AFx % of the sample will deviate by more than ADx milliarcsec from the median."

Quantity	Design Spec	Minimum Spec	Stretch Goal
AM1 (milliarcsec)	10	20	5
AF1 (%)	10	20	5
AD1 (milliarcsec)	20	40	10
AM2 (milliarcsec)	10	20	5
AF2 (%)	10	20	5
AD2 (milliarcsec)	20	40	10
AM3 (milliarcsec)	15	30	10
AF3 (%)	10	20	5
AD3 (milliarcsec)	30	50	20



Requirements applicable to MonoCam

Table 18: The specifications for astrometric precision. The three blocks of values correspond to D=5, 20 and 200 arcmin, and to astrometric measurements performed in the r and i bands.

LSST specifications: absolute astrometry

From
http://www.astro.washington.edu/users/ivezic/Publications/LSSTSRDv5.2.3.pdf

"The LSST astrometric system must transform to an external system (e.g. ICRF extension) with the median accuracy of AA1 milliarcsec"

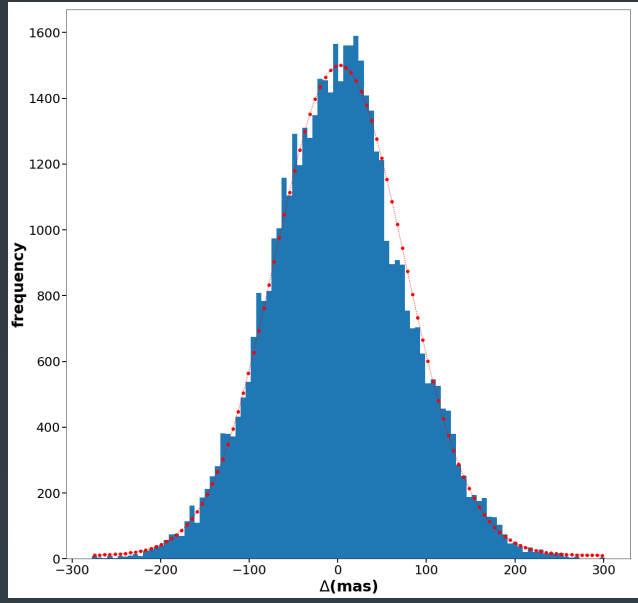
Quantity	Design Spec	Minimum Spec	Stretch Goal
AA1 (milliarcsec)	50	100	20

Table 20: The median error in the absolute astrometric positions (per coordinate, in milliarcsec).

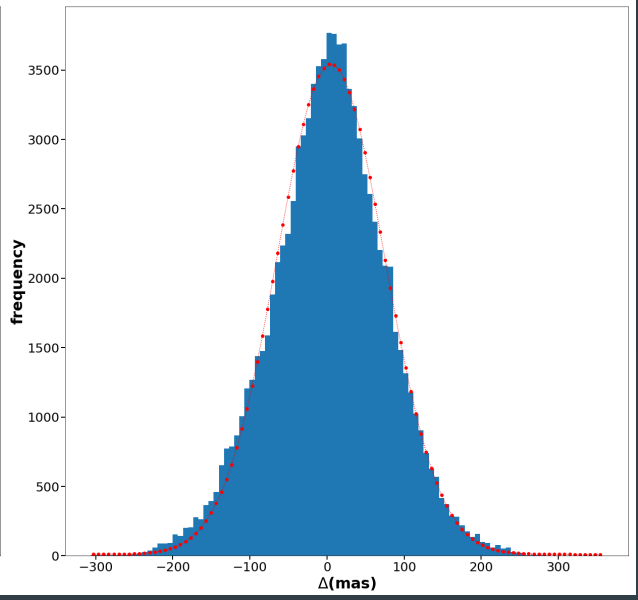
Catalog and source star distance comparison

- Found distance between two source stars and their associated catalog stars, then subtracted the two distances for Δ:
- Δ = (star dist – catalog dist)/sqrt(2)
- Next, we binned star distance values and calculated Δ per bin of star distance values
  - plotted the width of the peak as a function of source star distance

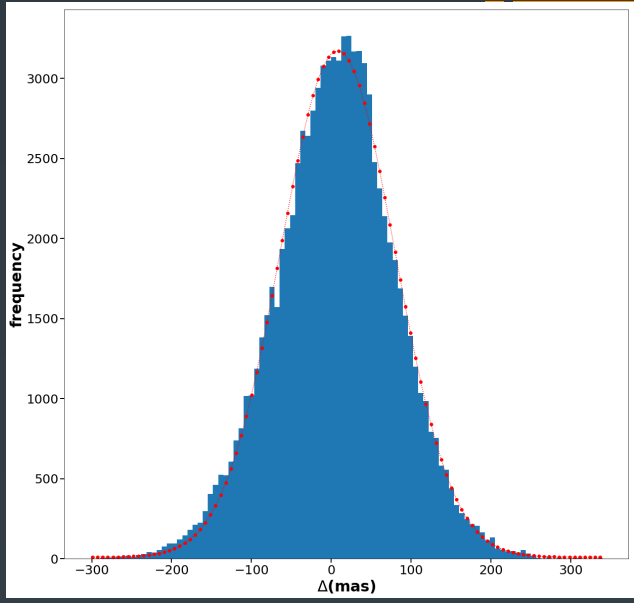
1st bin: σ = 73.26 ± 0.99 mas



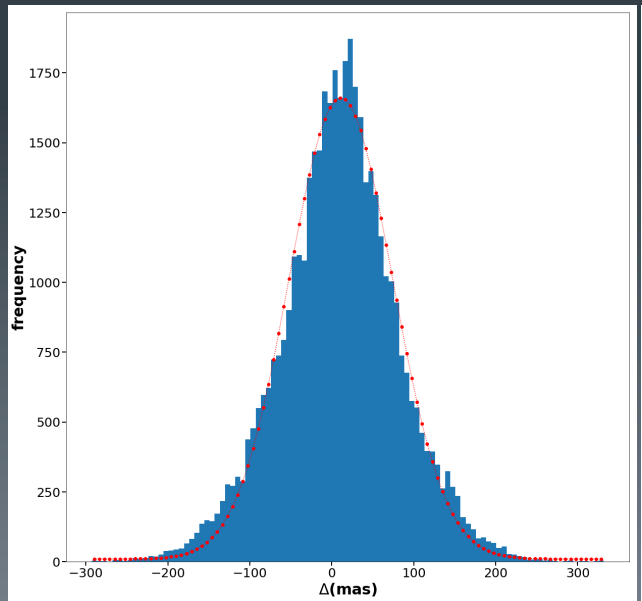
2nd bin: σ = 69.88 ± 0.70 mas



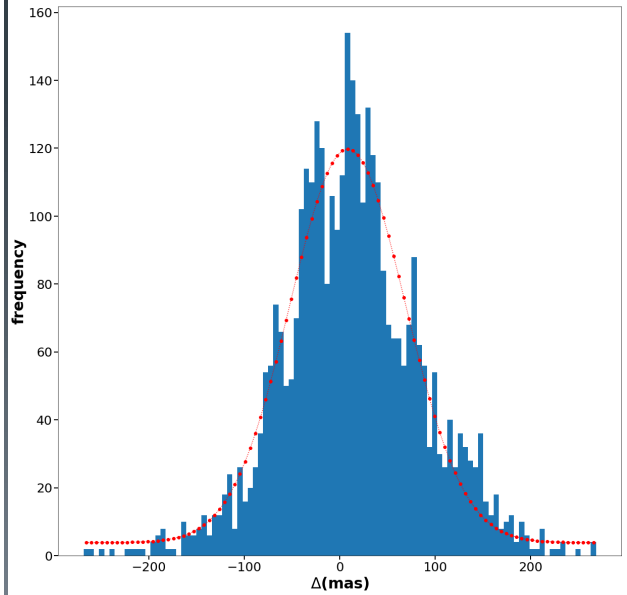
3rd bin: σ = 71.50 ± 0.65 mas



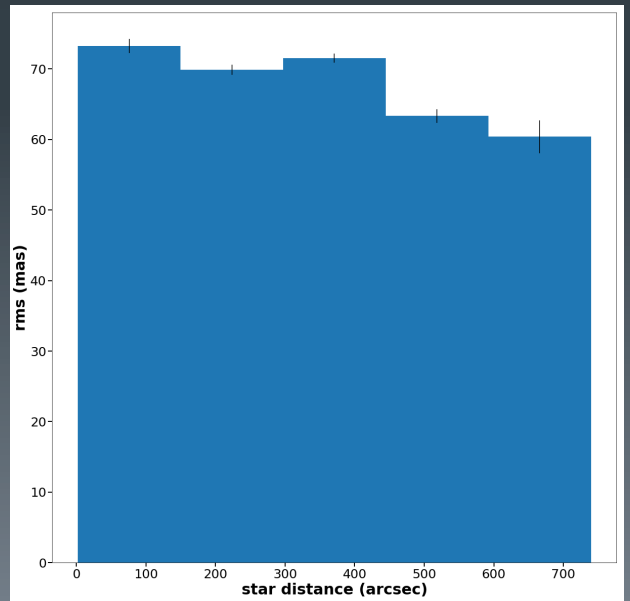
4th bin: σ = 63.31 ± 0.97 mas



5th bin: σ = 60.39 ± 2.33 mas

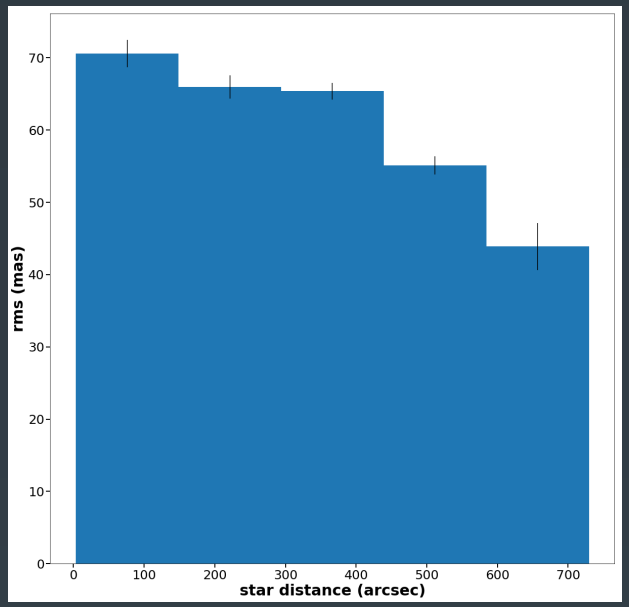


All bins, bin width 147 arcsec

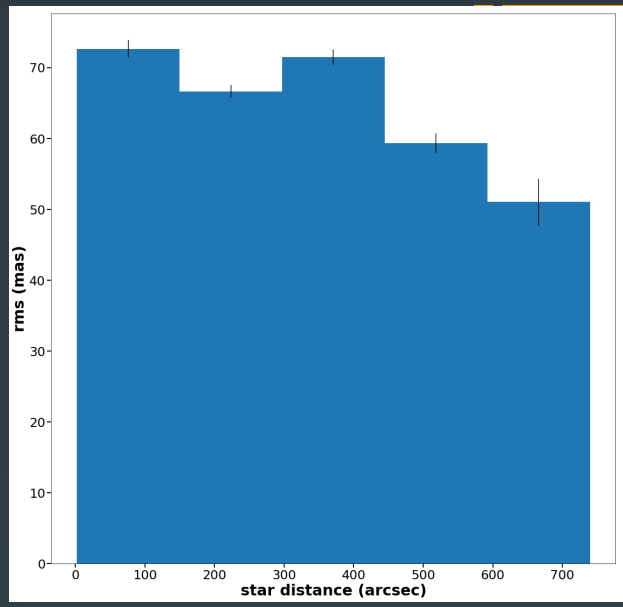


RMS plots for all filters using data from both days

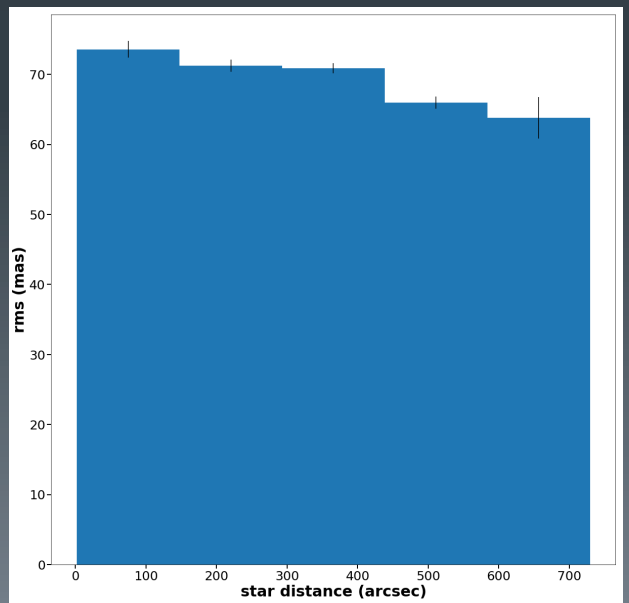
G filter rms plot



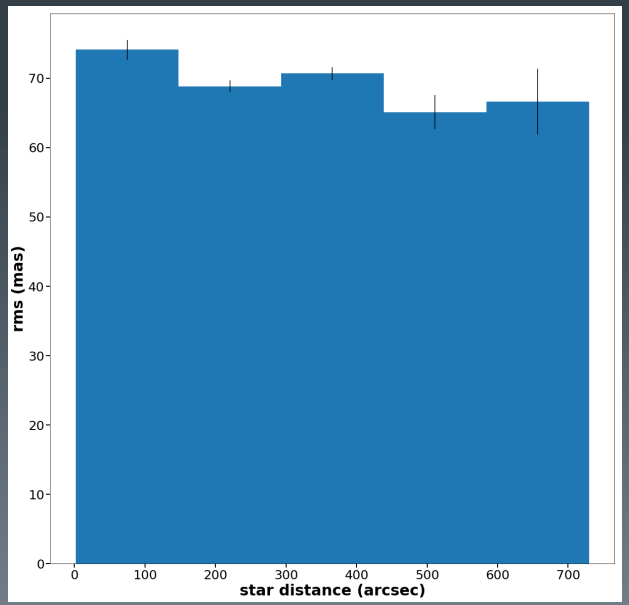
R filter rms plot



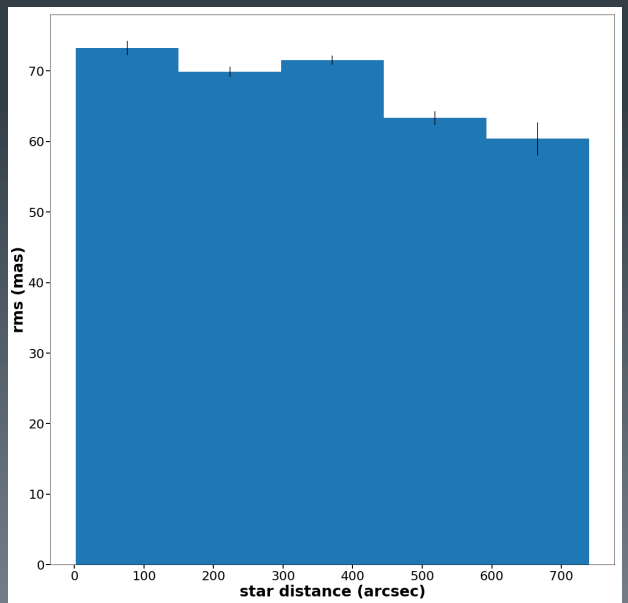
I filter rms plot



Z filter rms plot



All filters

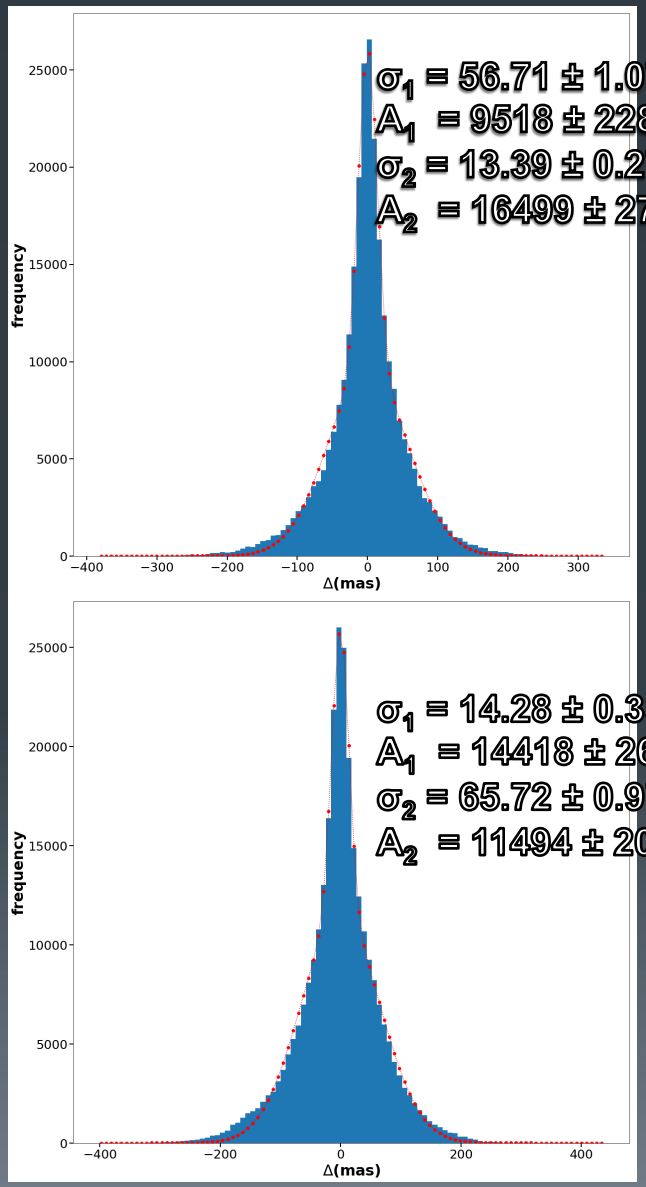


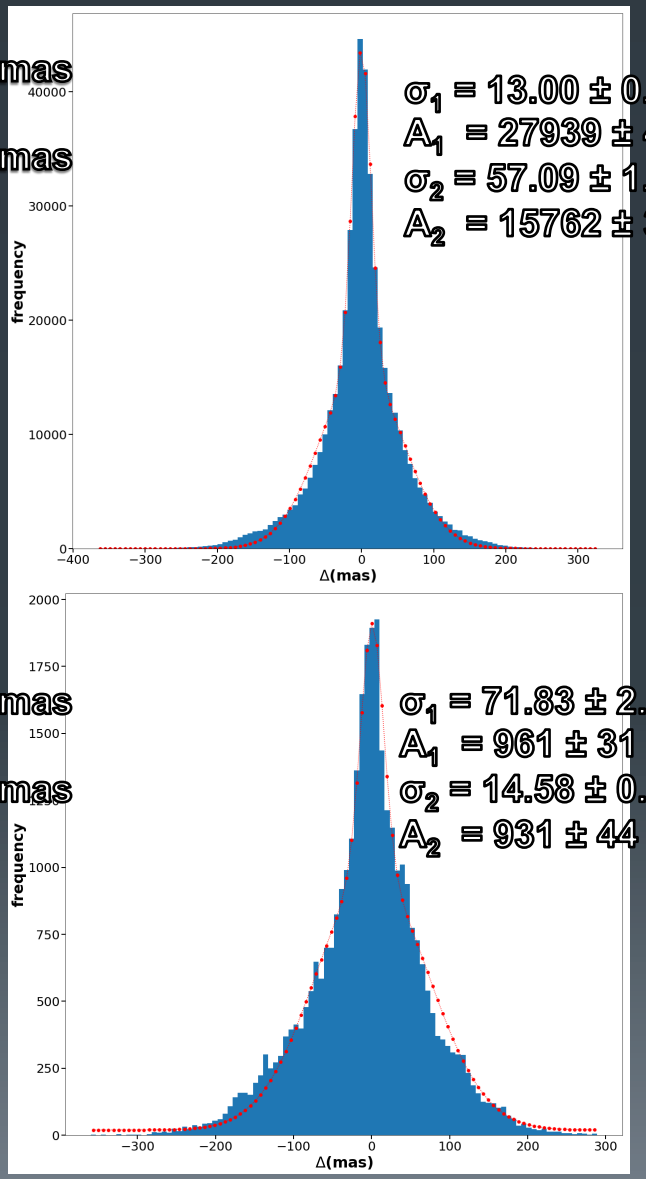
Visit-to-visit comparison cont'd

- Compared all visits from first day with all visits of second day, then all visits on the first day, and lastly all visits on the second day
- Used field lsst1532+1 only (field lsst1356+2 did not have any matches on first day)
- Fitted Δ plots to double gaussian instead of single gaussian since distribution did not appear to fit single gaussian well

Comparing day 1 visits with day 2

Note: bin width of 179 arcsec, binned distances into four bins (instead of five)





Summary

- Can’t find much evidence for distortions due to tree rings
- Switching to Gaia catalog seemed to slightly improve matching, though there are less matches per visit
- Catalog vs source rms plots showed downward trend as star distance increased
- Δ plots show different distribution for visit-to-visit comparison, narrower peak?
  - Fitting to double gaussian seems to do well